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BULLETIN

OF THE

AMERICAN GEOGRAPHICAL SOCIETY

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RESULTS OF AN EXPEDITION TO THE CENTRAL ANDES*

UNDER THE AUSPICES OF THE AMERICAN GEOGRAPHICAL SOCIETY

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Yale University

The three distinctive physiographic features of the Central Andes are a chain of interior basins with many salt lakes and vast marshy salars, the broadest and loftiest plateaus in the entire Andean Cordillera, and one of the few really great volcanic fields of the earth. In addition, a steep descent—a well-dissected fault scarp—defines the eastern margin, and a long barren coastal desert lies on the west. In the field of human geography the Central Andes form one of the most important groups of natural regions in the world. It is impossible to find elsewhere in South America an area of equal size with so great a variety of life. The density of population ranges from 100 to the square mile in the vicinity of Cochabamba, Bolivia, to $\frac{1}{10}$ to the square mile in the Territorio de los Andes, Argentina. Occupations run from the intensive agriculture of irrigated valleys to the pastoral nomadism of Alpine meadows; customs, from those of modern civilized people to those that bespeak an unmixed barbarism.

It is this extremely wide range in the physical conditions of the Central Andes that excites the interest of the geographer. The principles of geographic science rest upon the theory that man is to an important degree the product of the earth. In the varied physical environment of this great tract we should therefore expect climate and relief to exercise a high degree of influence upon the population. A study of its people should demonstrate both the scientific nature of geography and the wide application of its laws. Where then are the deserts, the vast river-threaded forests, the bleak tablelands, and barren mountain valleys? And what of man living under the stern conditions that these names imply? What is his life, his government, his character?

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* "The Central Andes" is a proposed name for a group of closely related natural regions that lie between 12° and 26° south latitude.

These considerations led me to undertake a line of work in South America that was begun in 1907[1], carried forward in 1911[2], and completed in 1913[3]. Notices and papers relating to the work of the first two expeditions have appeared in this *Bulletin.* It is proposed here to outline the principal results of the work of 1913. A preliminary note from the field appeared in the *Bulletin* for October, 1913. Later papers will deal with special problems; and the final results of the 1907 and 1913 expeditions will ultimately appear in book form. My warmest thanks are due the American Geographical Society for aid, without which it would have been impossible to complete the original plans. The generous spirit in which funds were appropriated is proof of the lively interest the Society is taking in field work as a basis of research.

In the account that follows I shall not attempt to give a narrative of the Expedition but shall leave that to the more extended treatment possible in the preparation of the final results; nor shall I include a complete account of the problems that were investigated. Thus little or nothing is said of the interesting physiography of the La Poma valley; the life of the Chaco territory; El Bramador, the roaring mountain of Toledo; geographic influences in the history of the early mining industry of Copiapó; the transmontane cattle trade and the effect of the rapidly changing trade routes of western Bolivia upon the fortunes of the highland people. It seems rather more appropriate briefly to outline a small number of leading problems.

THE EASTERN BORDER REGION

In the course of two earlier journeys to the Central Andes I had become acquainted with northern Chile, western Bolivia, and southern Peru. The field work in 1913 was therefore carried into northwestern Argentina where terminates the great chain of interior basins that occupy depressions in the central plateau. It

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[1] The Yale South American Expedition of 1907.

[2] As part of the work of the Yale Peruvian Expedition of 1911.

[3] Expedition to the Central Andes, under the auspices of the American Geographical Society of New York.

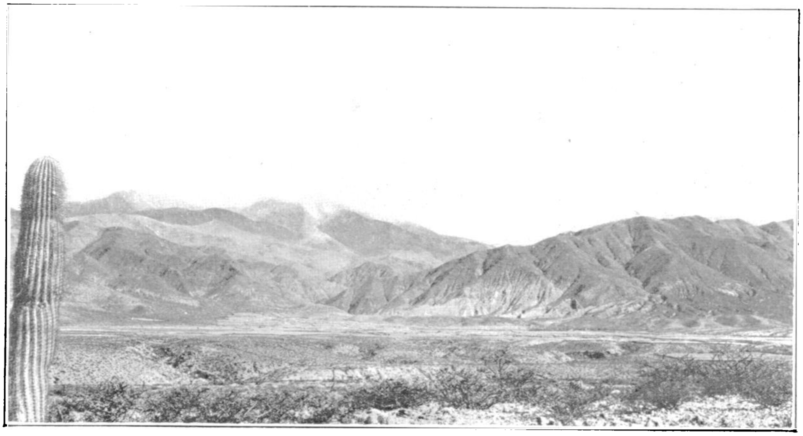

FIG. 1—Topography and vegetation at 10,000 feet, La Poma region, northwestern Argentina, lat. 26° S. Here occurs a valley desert where aridity combines with strong erosion to limit the amount of available water. Several thousand feet lower is the forest zone; several thousand feet higher are the grasslands of the Alpine country.

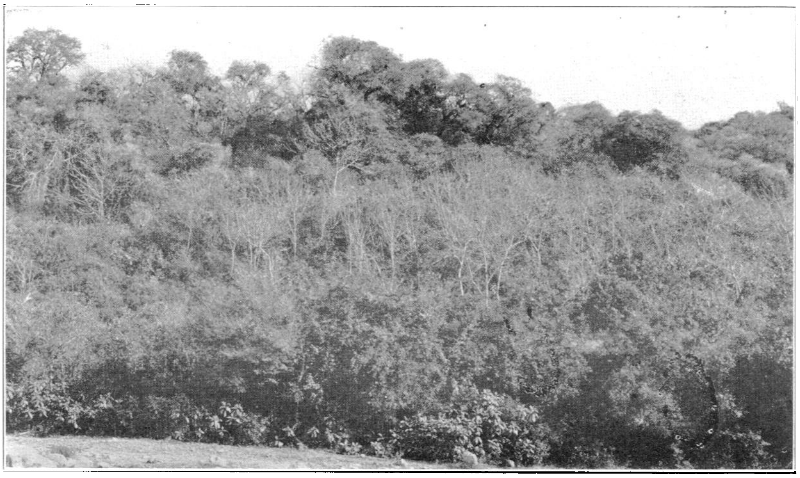

FIG. 2—Denser stands of timber in the forest zone that marks the belt of maximum precipitation above Rosario de Lerma, northwestern Argentina, 4,000-5,000 feet.

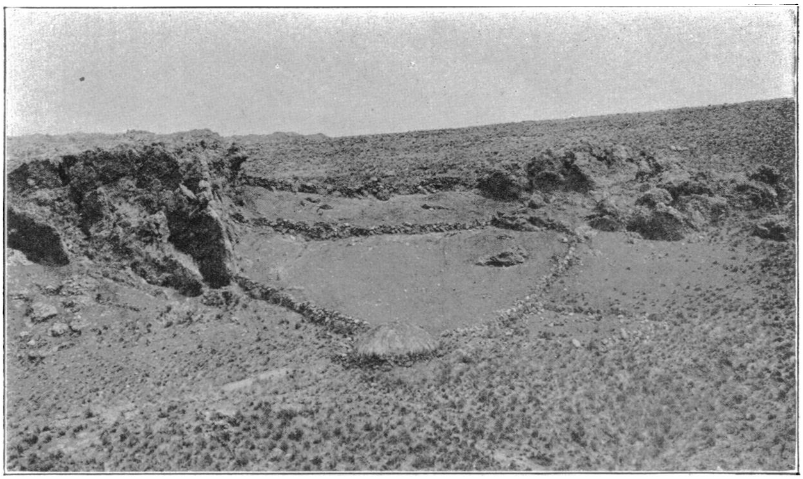

FIG. 3—Grass-thatched hut of a mountain shepherd, two days' journey west of Puno. *Ichu* grass in the foreground.

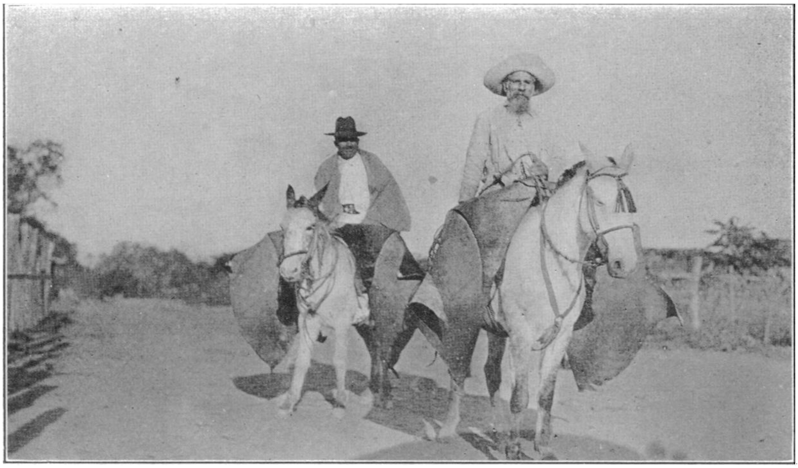

FIG. 4—Gauchos of the Chaco at Embarcacion, northern Argentina. The heavy cowhide flaps on the saddle front are a protection against the thorny shrubs through which the cowboy must ride in rounding up his stock for the long drive to the end of the railway.

is here also that the climate of the Central Andes is most extreme. The summer (January) sun raises the temperature to a high degree; the dust storms of midday hours give place at night to calms, and, in the clear skies of the horse latitudes in which the district lies, the thin air radiates its heat so rapidly as to fall below the freezing point. In winter, even the daytime temperatures do not rise above 35° to 55° F., and the night temperatures frequently fall below 0°F. The rainfall varies from ten to twenty inches on the eastern margin of the mountains to two inches in the driest parts of the Puna de Atacama. In the extreme climates of a region so broken and lofty the distribution and character of the population show striking responses to geographic conditions.

We found the zone of maximum precipitation on the mountains west of Salta to be marked by a belt of temperate forest between 4,500 and 6,000 feet. Above the forest, scattered groves occur in favorable places and belts of timber extend up the shadier and moister valley floors. The higher country bears a thin cover of herbaceous vegetation which gradually changes to the scattered clumps of *ichu* grass at the highest elevations. Up to 9,000 feet barley is grown; above that elevation potatoes are the chief vegetable product. The grasslands are the seat of pastoral population groups. In the forest, agriculture and grazing are combined. Below the forest a more intensive agriculture is practiced with irrigation. Those streams that have their chief tributaries in the forest belt are most constant in flow and furnish to the population groups on the mountain border the means for agriculture and stock raising on a large scale.

The variety of life on the eastern flanks of the Cordillera, due to the varied climate and resources that we have briefly sketched, is exhibited in a comparatively narrow zone owing to the abrupt nature of the mountain border. In a few days one may ride from the warm valleys at 4,000 feet to the bleak passes in the bordering ranges at 16,000 feet, crossing successively the belt of irrigation, the belt of forest and woodland, the belt of grasses, and the belt of barren mountain slopes and rock slides. It is but natural that there should be an intimate degree of intercourse between the people of these unlike regions. The wool and skins of the mountain shepherds are carried down by pack train to the railroad at Rosario de Lerma (thirty miles southwest of Salta); in the belt of forest besides vegetable growing ("habas", beans, potatoes, etc.) woodcutting is a regular occupation for a limited number, to supply timber and fuel to the mines and firewood and building material to the towns. The irrigated valley lands support herds of cattle and droves of mules for the transmontane trade with the nitrate country in the Desert of Atacama. So large and profitable is the trade since the fuller development of the nitrate industry that land values have risen enormously. Many families once poor land owners are now rich city dwellers. This is a phenomenon now common to the eastern agricultural provinces of Argentina but it is of recent development in the mountain provinces and in some cases is due to quite different stimuli: the railroad, the growing nitrate industry in Chile, the more rapid development of mining since the introduction of the railroad, and a host of minor causes.

Because it is the capital of the province in which these economic changes have been most marked Salta has been transformed in the last ten years. From a mountain village it has developed into a fair-sized city. Its people were once untraveled and its streets filled with pack trains bearing supplies that were in large part bartered rather than sold. Even its merchandise had only a few decades ago come largely from across the Cordillera, where Chilean railroads gave easier access to large commercial routes. Now it has a street-car line, big business houses, at least four large banks, and a considerable number of really modern homes. He who has visited Europe is no longer pointed out as a distinguished person. The dresses of the women are nearly as modern as may be seen on the streets of New York. One of the most elegant club houses in Argentina faces the well-kept plaza. The life of the people in a score of ways has taken on a degree of comfort and luxury hitherto almost unknown.

It is not possible to give within the limits of this short paper more than the briefest account of the work on the western border of the Argentine Chaco. It is here that cattle are gathered for shipment to the valley pastures at Salta and other districts on the west. From the railroad terminal at Embarcacion long lines of two-wheeled carts carry supplies northward to the Argentine-Bolivian border towns along the base of the mountains and to the oil fields at Cueva, Bolivia. A feeble down-stream trade by means of temporary rafts is carried on with the river villages below the Bermejo crossing. Through the terminal also come groups of Matacos Indians who spend part of their time on the sugar estates now developing rapidly on the plains along the border of the mountains. In oil, sugar, and cattle, we have examples of resources that are of much wider interest than the hides, feathers, wool, and grains for which the region was formerly known. It will therefore be

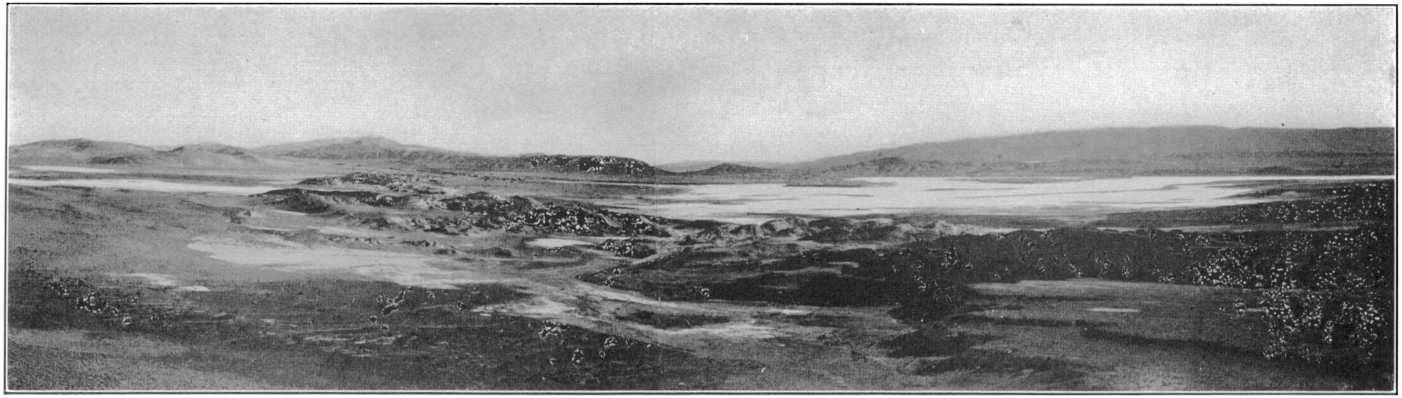

Fig. 5—The borax basin of Pastos Grandes, northwestern Argentina. In the background are lava flows. The white deposit is borax broken here and there by open water. The central hummocky ridge which separates the two parts of the basin is composed of basin sediments, finely stratified, thrown into low folds, and with a strong regional inclination toward the center of the present basin. The relations are typical of the three main basins along our route.

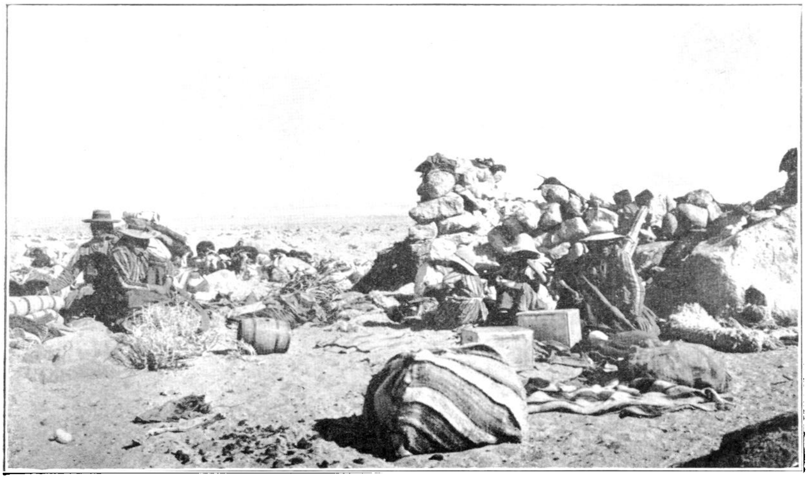

Fig. 6—Winter camp of mountain shepherds at Aguas Blancas near Soncor, Desert of Atacama, 9,000 feet. In the background is the great Salar de Atacama, the largest salt plain in South America.

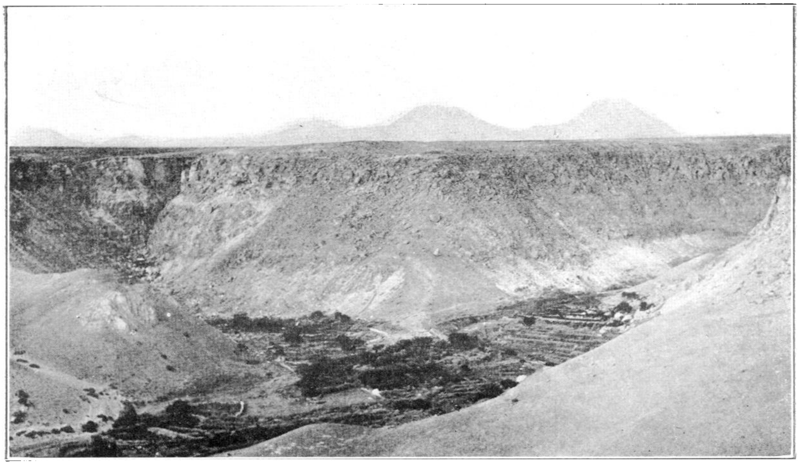

Fig. 7—Oasis of Soncor, western border of the Maritime Cordillera, Chile, where a small mountain stream terminates near the edge of the Desert of Atacama.

seen that the geographic importance of the region on the common border of mountains and plains in northern Argentina depends not only upon minor products of local value but also upon commodities that enter into national and even international trade.

THE PUNA DE ATACAMA

The physiographic studies which I have been able to carry out along five different routes running from one side of the Central Andes to the other make it possible to conclude that the whole region has suffered great uplift in relatively recent geologic time. In the Tertiary and early Pleistocene, uplift by at least 5,000 to 7,000 feet carried to its present elevation a relatively low-lying tract bordered by mountains of only moderate boldness. Were it not for the topographic irregularities caused by the volcanic eruptions of the period of uplift the mountains would be smooth-contoured, rounded, subdued. Their present ruggedness is due less to the great uplifts they have suffered and the dissection now in progress than to the volcanic cones and ragged lava flows built upon them.

The Puna de Atacama clearly exhibits this three-fold topographic complexity. It consists of a series of interior basins of great aggregate extent shut off on either hand from the Pacific and Atlantic drainage and also in general from each other by volcanic masses. Were one able to remove the volcanic material there would be revealed an older series of rocks on the one hand very complex as to structure and on the other very simple as to topography. Old schists, slates, limestones, and younger intruded granites, are faulted, folded, and mashed to such an extent that a detailed description of their structure would be hardly more than a long catalogue of facts. Few generalizations can be made save that the main structural lines trend with the topographic lines of the mountains. This implies repeated movements along established planes of fracture, repeated stresses along somewhat permanent axes, and at least some genetic relation between lines of fracture and folding and those recent volcanic outbursts that have increased the height and ruggedness of the mountains. Before the period of volcanic activity had set in, the topography had ceased in large measure strongly to reflect the structure. Erosion had been so long continued that the rugged forms of a youthful landscape had become the subdued forms of a late-mature landscape. Where volcanic material is absent as in the Pre-Cordillera, northeast of Tucuman, and in the ranges between Rosario de Lerma and La Poma, the older topography stands out in marvellous contrast to the ragged border of the sierras crowned by roughened volcanic material and cut into a labyrinth of spurs and canyons by a multitude of streams.

A high degree of interest surrounds the physiographic problems of the Puna because of the stage in the arid cycle that the topography had reached before the main volcanic period had opened. As we have just seen, mature forms were developed upon an older surface of erosion. Therefore in the pre-volcanic epoch, the basins must have had a greater degree of organization than they display in the present youthful stage of the current cycle. To say that their borders were worn down is to imply that their floors were built up with the waste derived from the eroded borders. If the basins stood at different levels the higher might have been filled up and become tributary to the lower and even the lower basins might ultimately have gained access to the sea. How far was this process carried? We know that there were interior basins in a dry climate before the volcanic epoch opened because locally developed sediments containing salt deposits are now visible on the margins of some of the existing basins. They are flexed upon the borders and thrown into low folds or faulted farther out; dissected on the borders and buried toward the center of the existing basins. These sediments are not coarse, irregular, local, alluvial-fan deposits like those that in part overlie them and that are in process of formation. They are even-bedded and extensive. They denote quieter and more gradual accumulation from an upland border well-advanced in the cycle of erosion. Furthermore, it is reasonable to infer that they overlie coarser deposits that were formed in the youthful stage of the cycle.

Whether the deposits of neighboring basins coalesced across the low divides or became at last interdependent it is not yet possible to say. It seems a fair inference, however, that they did. In even the present youthful basins there is a certain degree of coalescence of bordering waste deposits as between Quiron and Rincon (lat. 25° S). The basin of Huaitiquina now discharges into the Salar de Chanchari and the Susquez basin by the river Burras into Salar Grande. There are also a considerable number of minor basins in which the same condition has been attained. If this degree of coalescence has been gained in the youthful stage of the present cycle it is reasonable to infer that the basins had a much higher degree of organization in the mature stage of the preceding cycle. Soft forms, moderate gradients, and waste accumulation to a thickness of at least a mile on the border of the Cordillera

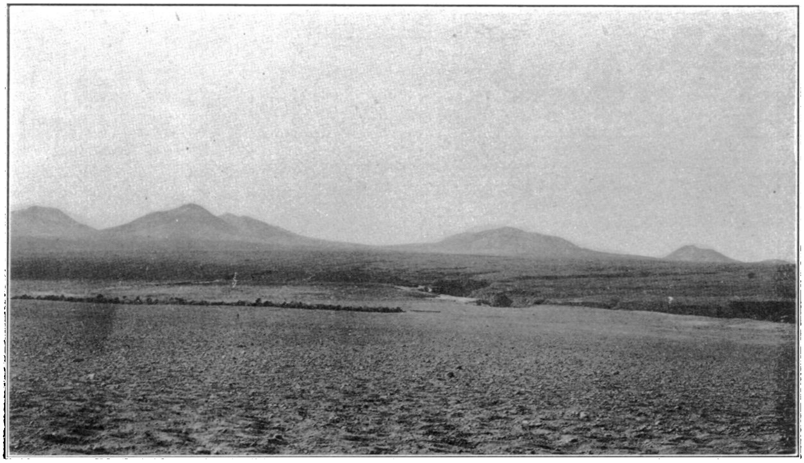

Fig. 8—Oasis of Toconao. Volcanoes of the Maritime Cordillera in background. One of the trails of the mountain shepherds may be seen as a white line leading from the oasis toward the mountains. Toconao is famous for its fruits and also for its good water, which is carried in pack buckets to San Pedro de Atacama, a day's journey toward the north.

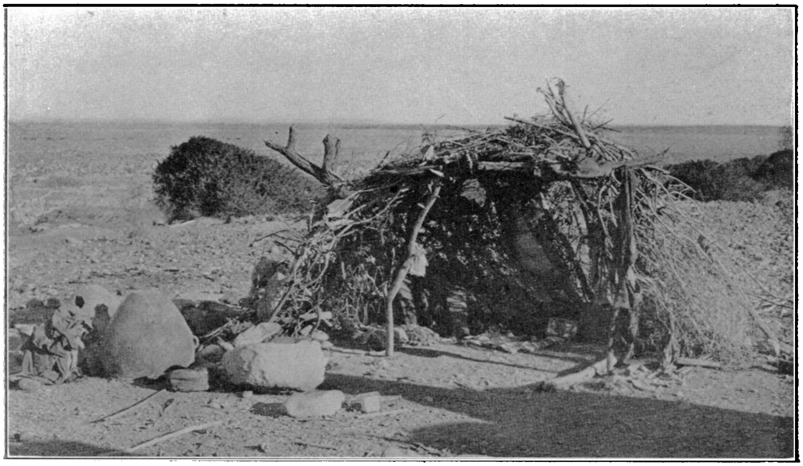

Fig. 9—Temporary habitation of poles and branches on the border of the oasis of San Pedro de Atacama, used by mountain shepherds on trading journeys to the oasis.

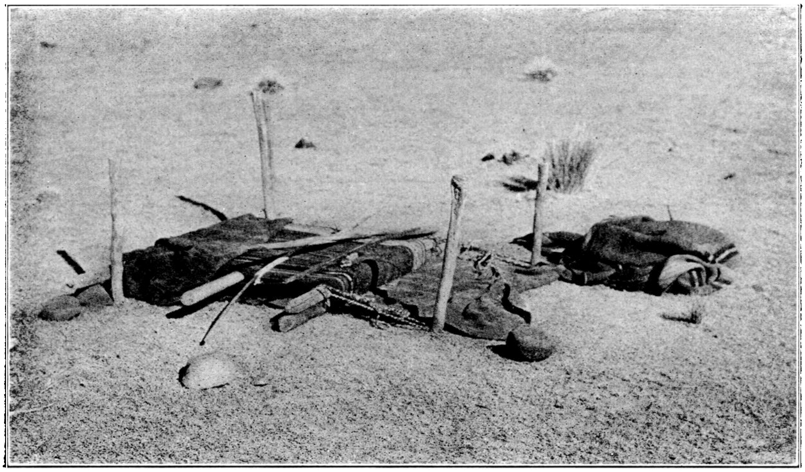

Fig. 10—Blanket weaving among the highland people.

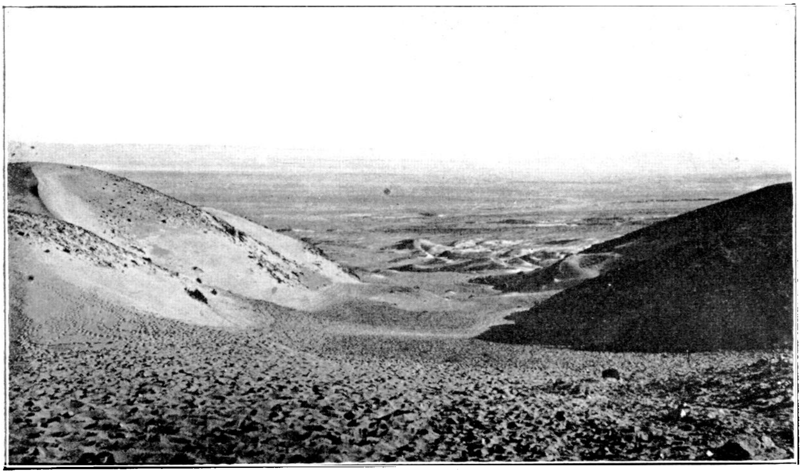

Fig. 11—The dune country on the border of the Desert of Atacama.

were achieved during the main cycle of erosion; it must therefore be concluded that basin integration was well advanced since the leveling action of desert processes fill up basin floors and thus raise the local base levels at the same time that the basin borders are graded and reduced in height.

In the Titicaca-Poopó basin on the north we have some suggestion of the state reached by the southern group of basins. Lake Titicaca discharges into Lake Poopó through the Desaguadero river. Poopó in turn discharges intermittently into the Salar of Aullagas. Between this and a number of other large adjacent salars there is now intimate connection. Though rock masses are distributed here and there through the group of basins, they no longer form continuous divides. They are either remnants of former more extensive ridges now partly buried, partly eroded, or volcanic masses of recent origin. In this region volcanic action was confined chiefly to the Western or Maritime Cordillera; it did not, as in the Puna de Atacama, affect the whole central basin region and obscure the earlier topography.

The light that the northern group of basins throws on the southern group is the clearer since the same stage in the erosion cycle had been reached by both. Mature forms everywhere characterize the borders of the Titicaca-Poopó basins save where volcanic material has been built upon the older surface. Long waste slopes, in complete organization with those cut upon rock, lead down by gentle gradients to the borders of the salars. Basin filling and integration are here in a advanced stage. It is conceivable that in the northern group less work had to be done to accomplish a given result. Were the basins less effectively separated from each other than those in Argentina to begin with? We can answer this question only in part. The Puna de Atacama is now a great highland with a general elevation that is quite uniform in spite of the volcanic material irregularly disposed upon it. From this I infer volcanic action to have affected less the regional elevation than the form and size of the local basins.

That the country was not built up to a general level by volcanic flows of a high degree of fluidity is shown by the fact that the older rocks, eroded to moderate gradients and marked by rounded forms, outcrop in many places and the volcanic flows are gathered rather closely about the volcanic vents. Uniformity of elevation may therefore be ascribed to moderately uniform reduction to a common level in the pre-volcanic erosion cycle. If we now consider the fine character of the earlier basin deposits it would seem that the basins in which they were formed were more extensive than they are today. But, as we have seen, great extent and uniform elevation of basins are also characteristics of the Titicaca-Poopó region. We may therefore safely conclude that the forms and relations of the Titicaca-Poopó group of basins indicate in a general way the topographic and drainage conditions of the Puna de Atacama before volcanic material had covered a large part of the region, masked much of the older topography, and altered the size and limits of the interior basins.

THE PASTORAL NOMADS OF THE DESERT

The lofty Puna de Atacama lies between 23° and 26° south latitude where in June the sun's noon altitude is only 45°. Unlike the northern basin region and the Andes of Peru, the Puna has a protracted winter season marked by high winds, very low temperatures, and occasional blizzards. In our coldest camp on the night of June 22, the temperature fell to —4° F. On June 25 we rode from 4 o'clock in the morning until daybreak in a temperature that dropped steadily from +6° to 0°F. When the wind blows the cold is extremely trying inasmuch as the altitude prevents hard exercise that results in brisk circulation and a higher degree of resistance. In crossing the last pass in the Maritime Cordillera on the trail leading down to Soncor, south of San Pedro de Atacama, we rode into a wind that occasionally blew at gale strength with the temperature ranging between 7° and 45°F. In the great storm of July, 1911, a number of chinchilla hunters and cattle drivers lost their lives; and over seventy-five cattle perished at Agua Caliente (14,500 feet) on the way between the plains of Argentina and the nitrate desert of northern Chile.

Once every few years even at San Pedro de Atacama (8,000 feet) crops planted in August and September are frost-killed in December and the fields must be replanted. Though snow is a rarity in the desert it fell in 1911 down to 8,000 feet. In the oases it covered orange trees, vegetable gardens, and grain fields and effected a glory that was as novel as it was short-lived. It covered the mud huts thatched with grain-straw mixed with earth, and on melting germinated the seed, so that more than one householder grew a small crop of wheat and barley on his roof!

The extreme dryness of the region is one of its saving qualities for it limits the amount of snowfall. Were the region only a little moister the snowfall would be greater and in seasons of bitter cold the combined snow cover and low temperatures would make it not

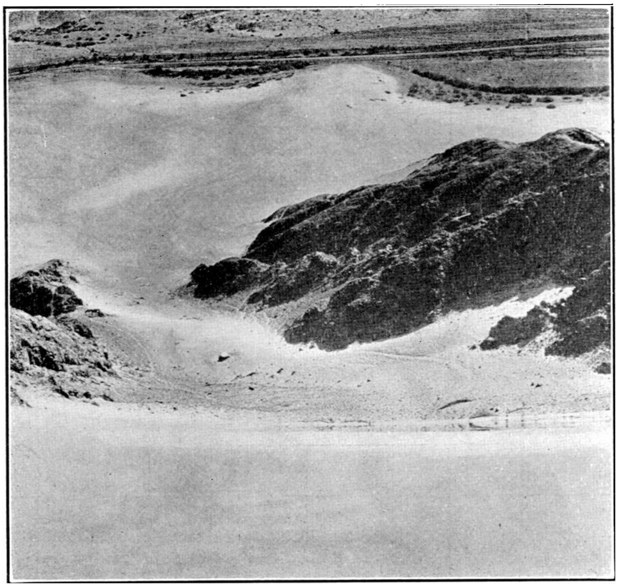

Fig. 12—Photograph of a mirage on a sand dune, west face of El Bramador, the roaring mountain of Toledo, near Copiapó. The camera is inclined downward at an angle of 30°. The mirage shows as a slightly darker band 1/16 of an inch wide, 1½ inches long, and 13/16 of an inch from the bottom margin. In a good print it appears like a shallow pond on a plain of sand.

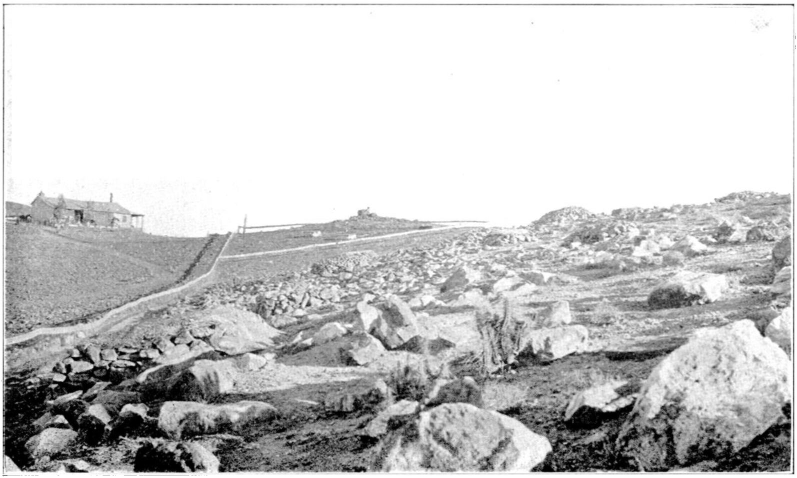

Fig. 13—A chinchilla farm on the ranch of Sir John Murray at Vallenar, Chile. The original stock of 500 has increased to 2,000. The stone mounds are artificial. A corrugated iron and wire-net fence keeps them from escaping.

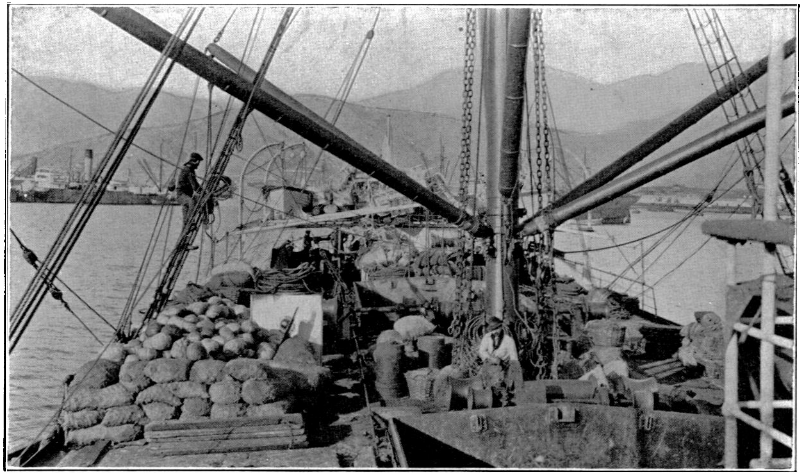

FIG. 14—Deck of the French freighter *Ville du Havre*, Lamport and Holt Line, showing vegetables in transit from the Huasco Valley to the nitrate ports. Coming south she carries vegetables to the desert ports from Arica which is supplied from the irrigated oasis of Tacna.

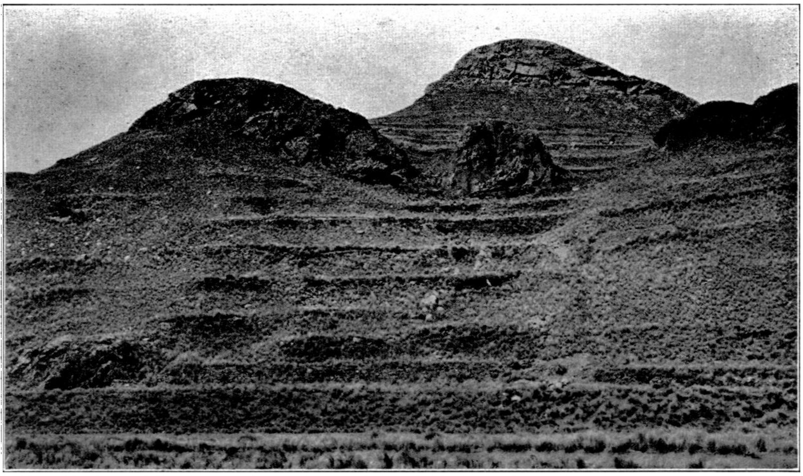

FIG. 15—Abandoned artificial terraces, called *andenes*, in the Cayrani Valley, a day's journey west of Puno, Lake Titicaca. Here once lived a much denser population, but the decrease is not due to a change in the productivity of the land or to a diminished rainfall. The population was drawn off in earlier years to the silver mines nearby and in later years to the towns and to the estates of the landed proprietors.

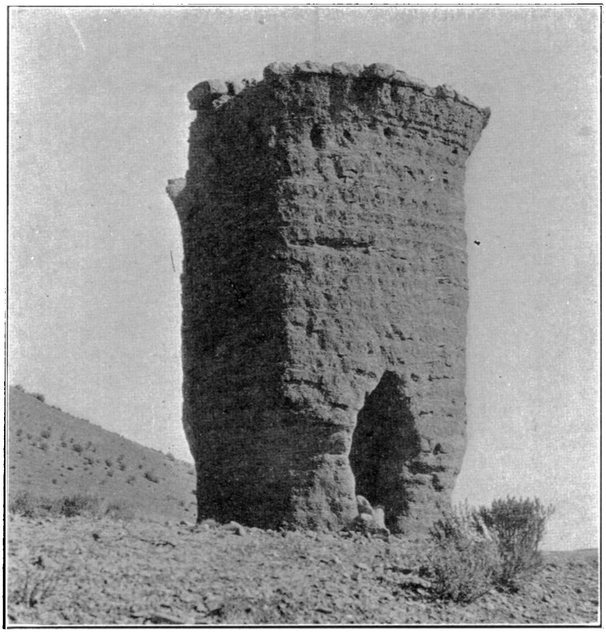

Fig. 16—Ancient chullpa in the Desaguadero Valley near Fairweather Gap. The thin partings represent layers of tough grass, bent back on the inside toward the outer face so as to give a smooth interior. The top is flat on the outside but dome-shaped inside. Under the floor are the skeletons of the former inhabitants. The door is about six feet high. The chullpa dwellings are no longer inhabited.

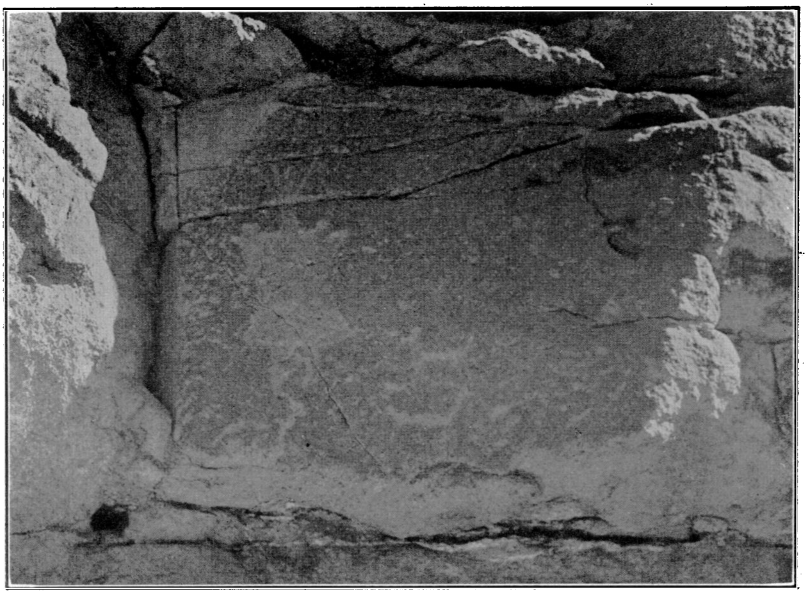

Fig. 17—Petroglyph near San Pedro de Atacama, exhibiting a chinchilla skin and llamas cut into sandstone.

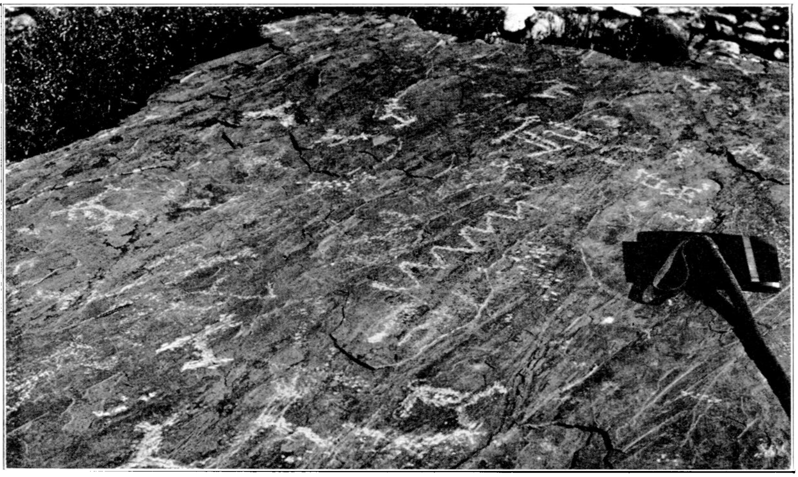

Fig. 18—Petroglyph in the making, near Piedra Blanca, west of La Poma, elevation 13,000 feet. The outlines of llamas may be clearly seen; likewise the zigzag pattern of a snake as well as symbols whose meaning is not clear. The notebook is eight inches long.

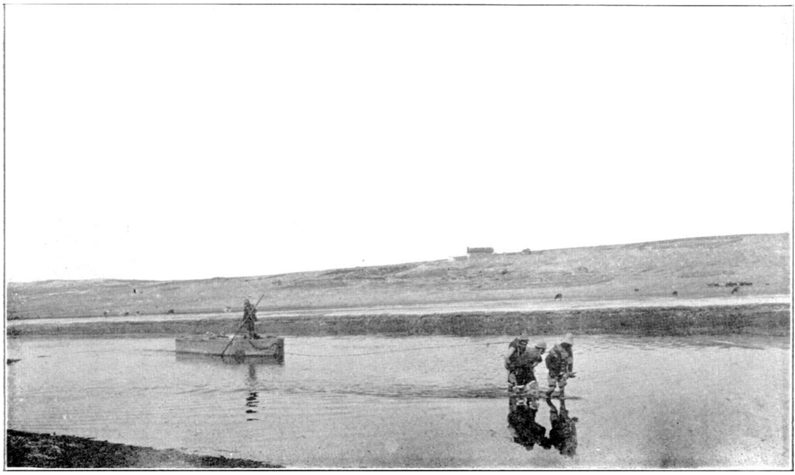

Fig. 19—Indians towing the Expedition's flat-bottomed, shallow-draught boat, below the limit of steamer navigation, Desaguadero River.

only uninhabitable but also untraversable. Except for intervals of a few weeks in times of storm, mails are carried across the mountains by "mule express" in six days and nights between La Poma in the Argentine and San Pedro de Atacama in Chile. No mail whatever could be carried if the snow cover were of notably longer duration.

Instead of the fixed climatic conditions of the trade-wind belt in the northern Central Andes we have here a zone where alternately trades and horse-latitudes hold sway. The balmy days of "El Verano de San Juan" in June or the calm weather of a few weeks in summer are rare exceptions. More common are the high and bitter winds of winter that drive the traveler to sheltering angles in the canyon wall or behind every stone large enough to protect his body. In summer the wind raises great clouds of dust which are almost as fatiguing as the low temperatures of winter.

One of the most important results of the dry Puna climate is the great distance between springs and streams, commonly 30 to 40 miles. Where seepage water from a large area gathers on a valley floor of limited extent useful grass may grow, but in the great expanses between seepage lines and springs there are only useless shrubs and ground moss. In the northern Central Andes, every part of a mountain valley yields something useful to farmer or shepherd. In the Puna there are no pastures on the loftier pampas. Only from 11,000-13,000 feet where clouds gather in winter and where summer rains are most frequent is there a belt of pasture, called *pajonal*—delicate green in summer and light yellow in winter—that may be seen from far across the bordering desert on the west. Below this belt, as above it, there is nothing of value to farmer or shepherd except where some mountain stream sinks into the coarse alluvium of the piedmont plain. When the shepherd is driven from the upper *pajonales* he has little choice of places to go. The desert oases may be crowded but there his flock must ultimately be driven. The sole though temporary alternative is to seek out the neglected spots where tiny springs water a narrow ribbon of green. There his flock flits from one clump of shrubbery to another or gathers in greedy rings about rare hummocks of grass.

The mountain shepherds are stunted in mental development by the harsh climate and slender resources of their cold valleys and high pampas. Otherwise we might expect an armed contest for food between the oasis dweller and the mountain shepherd. Actually we find that there is the closest and friendliest relation. The causes for this condition lie not only in the mentality of the Indian;

it lies also in the geographic distribution of his principal natural resources. The oases on the western border of the Cordillera are for the most part mere dots in a vast desert. Miles of almost naked lava separate them from the belt of mountain pastures. Miles of hot sandy piedmont separate them from each other. In the absolute desert about them their own flocks, had they any, would find subsistence for only a part of the year. Hence the small size and scattered distribution of the oases make them quite as dependent on the flocks of the shepherds as the shepherds are dependent upon the vegetable food of the oases. Indeed, this supplementary relation is carried so far in the case of the smaller oases that they are merely the winter camps for the mountain shepherds who have their own gardens which they leave to the care of the old and infirm during the greater part of the year. At Tilamonte a few patches of land are planted, then left to the care of wind and sun until the harvest is due. Above Toconao the villagers each year go up to a line of tiny springs to cultivate a few additional acres. Almost the whole population of Soncor and Socaire are in the mountains in summer, leaving windows and doors barred and gardens cared for by the feeble who are left behind.

Along the line of a single valley like beads upon a string are the scattered plots of precious watered land. Between them there may be nothing but gravel-strewn stretches of valley flat. Hence it is natural that each cultivated tract should be known under a different name and give its name to a part of the valley. The best illustration is to be found in the valley of Rio Atacama. The town of San Pedro de Atacama has about 500 people but all about it (and to the inexperienced traveler they appear a part of it) are scattered groups of families and little villages. All told they raise the population of the district to 2,000. On the maps the name of San Pedro de Atacama is applied to the whole collection of groups. Among the Indians each group has a distinct name and even the central part is not called San Pedro but *Conde Duque*. For two leagues above this nucleus are small cultivated tracts, Cuchaloache, Catarpe, Tambillo, Silo, and Quito where fruit is grown. Extending to a point three or four leagues below are Sólar, Larache, Yaye, Pácsar, Chécar, Séquitor, Coyo, Tulur, Beter, Poconche, Solcór and Cúcuter on a ridge of sand, and Tevinguicha on the border of a brackish swamp due to seepage from the piedmont deposits. Each village represents some natural advantage. Here a group of algarrobo trees feed on the ground water and supply an abundance of

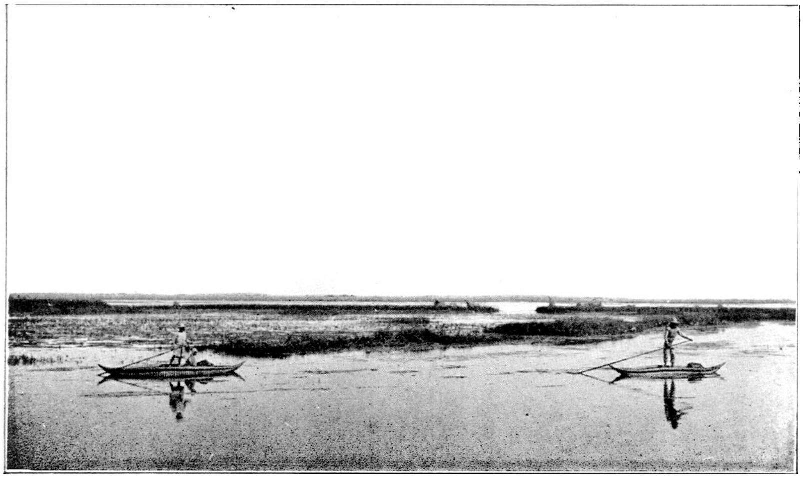

Fig. 20—Uros Indians in reed boats in the Totoral or great Desaguadero reed swamp, south of Lake Titicaca. The boats are propelled with long, slender poles brought from the forests on the eastern border of the Andes.

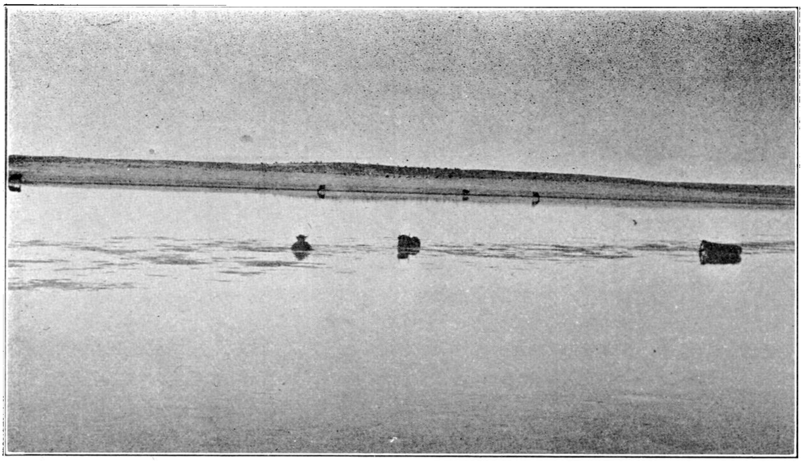

Fig. 21—Cattle feeding on the green, succulent water grasses in El Totoral swamp, Desaguadero Valley.

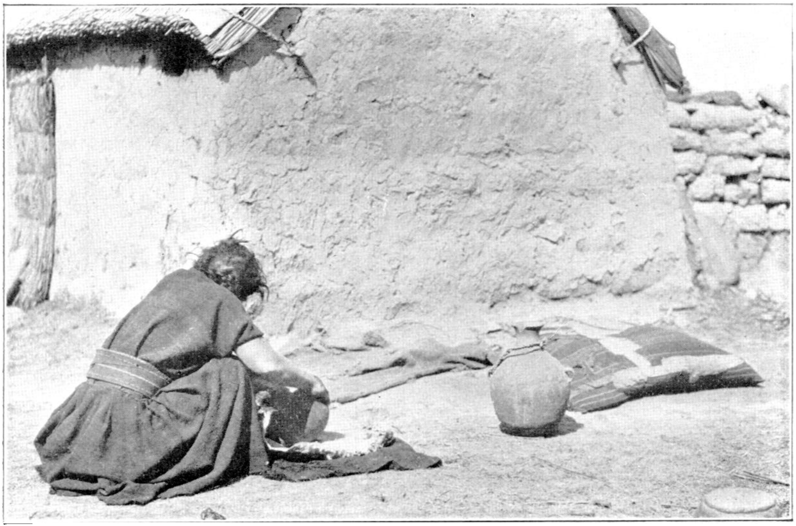

FIG. 22—Uros Indian woman grinding millet in a goatskin. The grinding stone has been brought from a rock outcrop several miles away. The sack contains llama dung, called *taquia*, and used as fuel. The reed thatch of the mud hut is secured by grass ropes fastened to pegs in the wall.

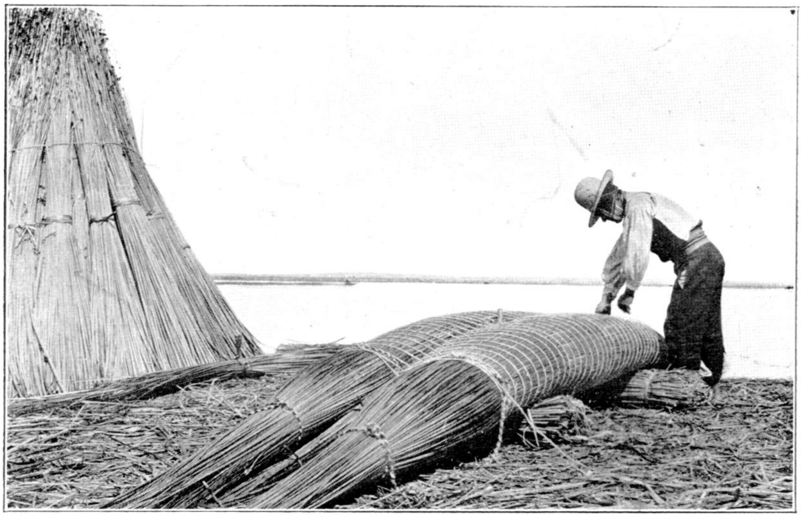

FIG. 23—Uros Indian making a reed canoe on the border of the great reed swamp of the Desaguadero, fifteen miles south of Lake Titicaca. The rope with which he is binding the reed bundle is made of grass. Note the cattle far out in the swamp in the background.

algarroba fruit. There a clump of chañar trees supplies nuts for the delectable chañar meal. On the edge of the swamp of Tevinguiche is pasture to be rented to the cattle drivers from across the Sierra. The soil is sandy at Cúcuter but it also has no harmful salts and if watered but twice a year yields good crops. At Catarpe are warm terraces easy to irrigate, hence beautiful fruit orchards.

San Pedro de Atacama is a city of arrieros (muleteers). Unlike its tiny neighbors it draws upon outside resources. The additional population which it supports requires food in amounts greater than the land can yield. Its wants are more varied. Through it also flows a commerce between the mountain peoples and the outside world. At San Pedro we should therefore expect trading customs and movement of population quite distinct from the feeble movements between the tiny oases. From their valley homes and upland pastures the shepherds come for the supplies of chuña, chañar, dried fruit, wheat, and flour. Their dependence on the town is so great that in many cases they construct two huts, one at the home oasis in a quebrada miles away; another in the desert on the border of the gardens that surround San Pedro. They pasture their flocks on grasses and shrubs nearby, rest a few days, trade, and return. A few have even gone so far as to construct a third hut on some neglected patch of land at the common border of desert and irrigated land and there plant a few grains and seeds to help out their slender resources. Among the oasis products are a few which they have grown very fond of—chañar, for example. In very dry seasons the crop may be small and the owners unwilling to part with it. Then the nomads refuse to sell their ropes of twisted llama wool. Now the arrieros of the town must have these to hobble their beasts at night while on a journey across the desert. Leather thongs would chafe the legs of the mules and start troublesome sores. Moreover, they cannot be so securely tied and the security of one's beasts is a most important care in desert travel. If the shepherd will not sell his valuable llama wool ropes for money the arriero must exchange for them something of less value to him. Thus he reluctantly parts with his crop of chañar nuts, for which he may substitute wheat, rather than do without the wool ropes for which he has no substitute.

In the communal vicuña hunts, now of great antiquity, these pastoral nomads on the western flanks of the Andean Cordillera show most clearly their isolated condition. Elsewhere the ancient customs have largely disappeared. The priest has substituted the ceremonies of the Christian church for the old feasts of the harvest and the chase. But the poor shepherds of the desolate country on the mountain border of Atacama still retain their old ways. Some of them are in pure form; even those that have become modified still have a strong flavor of the original paganism. Among them the vicuña hunt is by far the most interesting. Late in February or early in March, four or five days after the carnival of Chaya, the men of Aguas Blancas and Toconao go into the mountain country in search of vicuña. On the fifteenth day after the carnival the villages are almost depopulated. The women are busy stringing threads across the valleys down which the animals are to be driven for the vicuña will not pass a thread or rope stretched across his path. The men scatter widely in order to keep the quarry in the ravines. The hunters are mounted and when the vicuña become confused and huddled they are easily shot. He who kills a vicuña gets the skin, the most valuable part. Thus there is a strong incentive to compete in achieving the hardest part of the hunt. The rest of the animal is common property; since the hunt is cooperative all must share in some way in the spoils.

Of equal interest are the people of Antofagasta de la Sierra. In that small village on the floor of a canyon, remote and almost inaccessible in winter, live a group of shepherds that have but feebly responded to the movements of population and commerce about them. In the last hundred years they have belonged in turn to Bolivia, Chile and Argentina, without realizing the change. At last, title to their disputed territory passed definitely into the hands of Argentina. When the government made itself known they petitioned to be allowed to live on the land without the trouble of securing documentary titles and with all their ancient rights intact.

The degree to which pastoral conditions have guided the form which many customs have taken is perhaps best shown in the most important social relations of the people. It is not a disgrace for an unmarried girl to give birth to a child, or even three or four children, before marriage. On the contrary, it is a distinct advantage. Even small children, four to six years old, may guard large flocks of sheep. Hence the larger the number of children a woman can bring to her marriage feast the better pleased her husband will be. The children are therefore an asset; they constitute their mother's *dot*. Nor need they all have the same father. In short what would seem to us to be gross immorality is here regarded as a virtue though perhaps less because of any clear ideas of virtue than on account of a low stage of development and the practical

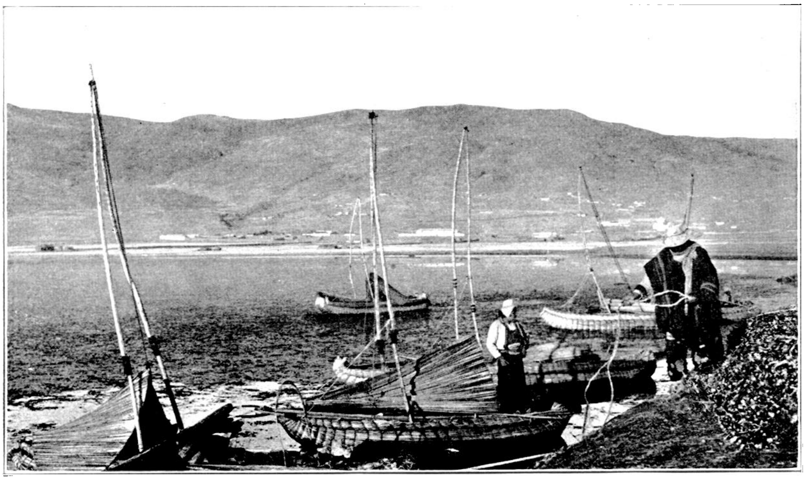

Fig. 24—Reed boats on Lake Titicaca. The thicker construction, as contrasted with the long slender lines of the Desaguadero boats, reflects the stormier nature of Lake Titicaca. The strongly upturned bow and stern enable the canoe to rise over waves of considerable height. The boats make so much leeway that they are sailed chiefly down the wind. These traders have been waiting two days for a favorable offshore breeze.

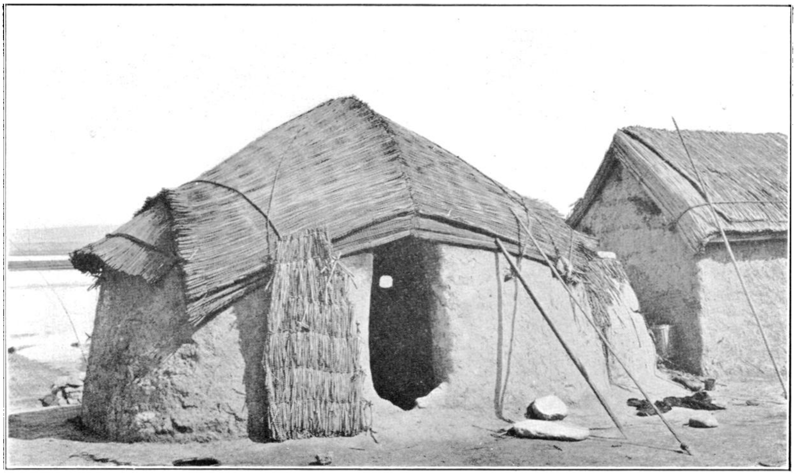

Fig. 25—Reed-thatched mud huts of the Uros Indians at Ancoaqui, Desaguadero Valley. The house on the left is a distinctive type with rounded corners and a mansard roof, adapted to the length of the reeds and the rounded walls.

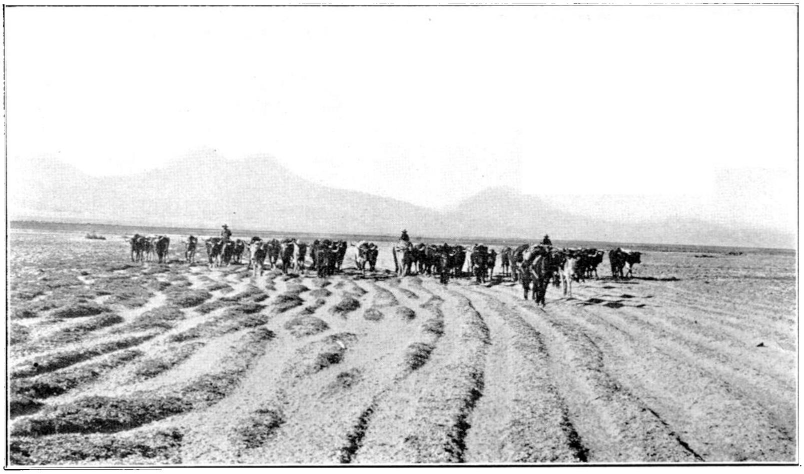

Fig. 26—Chaco cattle in the Desert of Atacama, after a twelve days' journey across the Cordillera between Salta, Argentina, and San Pedro de Atacama, Chile.

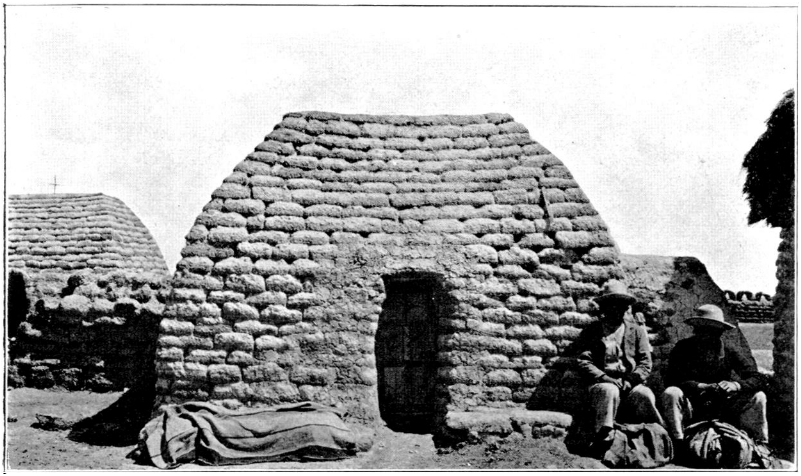

Fig. 27—Sod huts at Titipata, Desaguadero Valley. The thick-rooted, short grasses make a turf which has resulted in a different type of building material from that used elsewhere. This style of roof, adopted by people remote from forests, also avoids the use of rafters and ridge pole.

relation the custom bears to the business of securing a living under extremely hard conditions.

THE TRANSITION BELT OF COPIAPÓ

Southward from the almost rainless Desert of Atacama, in Chile, there extends a belt of country in which light, uncertain rains occur. The farther south one goes, the more frequent become the showers until in the latitude of Santiago they yield rain sufficient for agriculture, though it is only when we reach the Maule Valley 150 miles farther south that the amount exceeds 30 inches a year. In the Copiapó Valley the average is about two or three showers a year. In the Huasco Valley, one hundred miles south, there are twice as many showers and three times as much rainfall. This is then the transition belt between horse latitudes and westerlies where we find great variability in rainfall and in life conditions in places only a few degrees apart.

Ever since reading Darwin's famous description of them I have been eager to visit the valleys of the transition belt and gain some idea of the effect of the variable rains upon the life of the people. The study of the Tarapacá desert in northern Chile (1907) greatly increased my desire to visit the more southern valleys, and this at last became possible in July, 1913. Fortunately from the standpoint of geographic study, the region had suffered for several years from one of the most severe droughts in its history. On every hand I heard with what difficulty enough water was secured to keep the alfalfa meadows from drying up and the cattle from starvation.

Though there is more water at Vallenar, in the Huasco Valley 100 miles south of Copiapó, the same complaints were made there. It was predicted that rain would surely fall, because no rain had fallen for three years in succession. One day great masses of black clouds came rolling up from the south, rain was confidently predicted, and telegrams were sent to absent owners at Santiago. It was a novel experience to find water so important there that messages are sent whenever it looks as if it *might* rain! But the clouds dissolved in the late afternoon and I was disappointed on leaving to have missed a rainstorm in famous old Vallenar. At the suggestion of one of my hosts I left my future address, so that he might telegraph me news of the first rain.

A single heavy shower benefits pastures and fields and brightens the outlook of hundreds of people. Two showers bring a year of plenty, and three or more showers make the year memorable, if indeed they do not bring floods and greater disaster than several years of drought. Eight years ago there were extraordinary floods at Vallenar; fertile fields were covered with coarse gravel; landmarks were swept away; and large tracts of land on the valley floor had to be not only reapportioned, but resurveyed. Tierra Amarilla, a village a few miles above Copiapó, was wholly undermined and the houses carried off in the flood of 1906.

The rivers of this whole region commonly do not reach the sea as a surface flow. They terminate in the alluvium that chokes their lower valley stretches and thus effect a subterranean discharge. Their normal condition is modified in years of high water. The rivers are then extended to the shore and great masses of waste are swept out into the ocean. Thus in 1888 the Copiapó River reached the sea, whereas now it terminates many miles inland in a salt-incrusted flat overgrown with low, gnarly shrubs and coarse grasses. The Rio Algarrobal (latitude 28° S.) last reached the sea in 1906. For years it had terminated above the pueblo Algarrobal, but in the four wet seasons succeeding 1902 it flowed to the end of its valley. Thus we have here, in the horse-latitude belt near the border of the westerlies, a type of drainage distinct from (1) that in the still drier north where the mountain streams terminate on the land, and (2) that in the wetter south where the streams always reach the sea.

The two elements of greatest importance in the study of the relation of the people to water supply in this border region are the local showers and the distant mountain snows. The showers are nature's gift to poor and rich alike; the snows, melting, discharge by way of rivers, and river water can be used only by the landowner who lives on the valley floor. Furthermore, the larger the estate the more water it is entitled to use, hence a greater disparity between the financial condition of the small and the large landowners in years of low water. The resources of the rich enable them to weather the temporary difficulties which years of drought inevitably bring. By contrast, the poor landowner may be forced to sell his farm and stock at just the time when they bring least. To him the droughts may mean not only distress but ruin.

In earlier years when there was a purely local market for farm products the rains were not an unmixed blessing. The owners of hired troops of mules, the cattle importer, the miner, were all benefited, since their stock found free forage. But the landowner who made a business of renting pasture or selling hay found his income reduced, because the lower prices of wetter years more

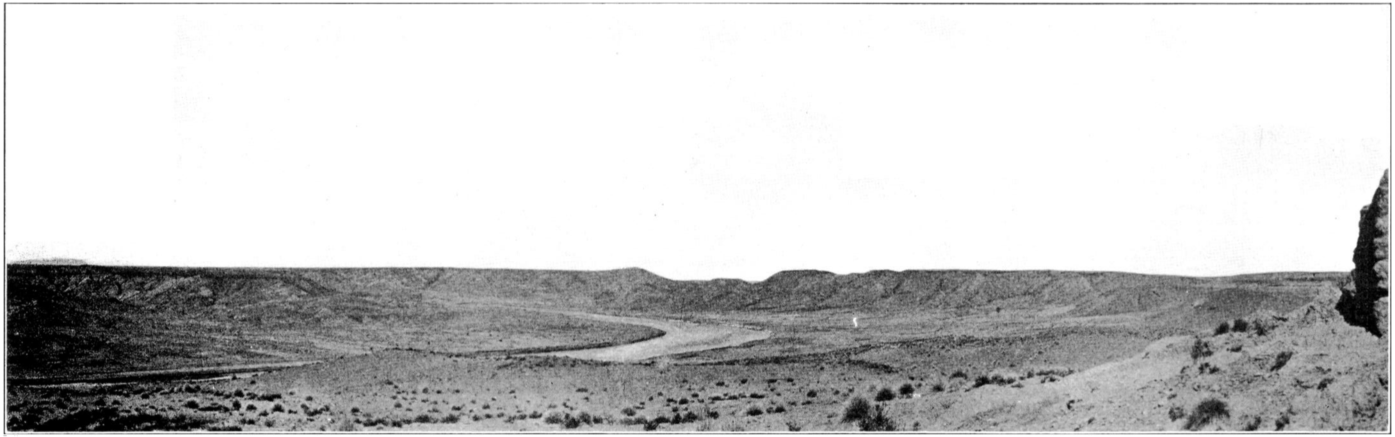

FIG. 28—Looking down (south) the Desaguadero Valley at Fairweather Gap (center). In the bluff on the extreme right (foreground) are stratified sands and clays, the deposits of Lake Ballivian. At their level in the right background are similar beds thinning out toward the skyline. The same beds in similar relations may be seen in the left background. The older sedimentary deposits on which they rest dip strongly toward the left (east). They are in part of Cretaceous age, in part Permian, and were beveled off to form a local peneplain before the deposition of the lake beds. (See Figs. 29-33.)

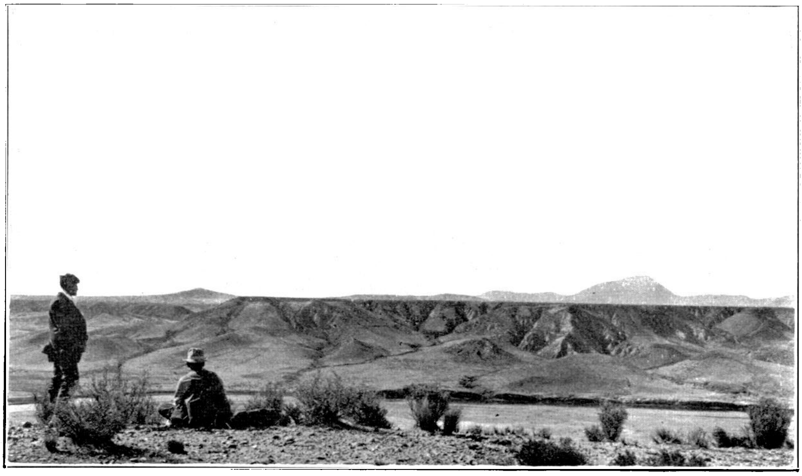

FIG. 29—Looking east across Fairweather Gap. In the background, extreme left, the deposits of Lake Ballivian rest like a thin wedge upon the inclined sediments that outcrop on the opposite side of the Gap and dip away from the observer (east). The hill on which the camera stands is 210 feet above the Desaguadero River, which may be identified easily. The river is here 46 feet below Lake Titicaca. The difference, about 160 feet, represents the elevation of Lake Ballivian above Lake Titicaca.

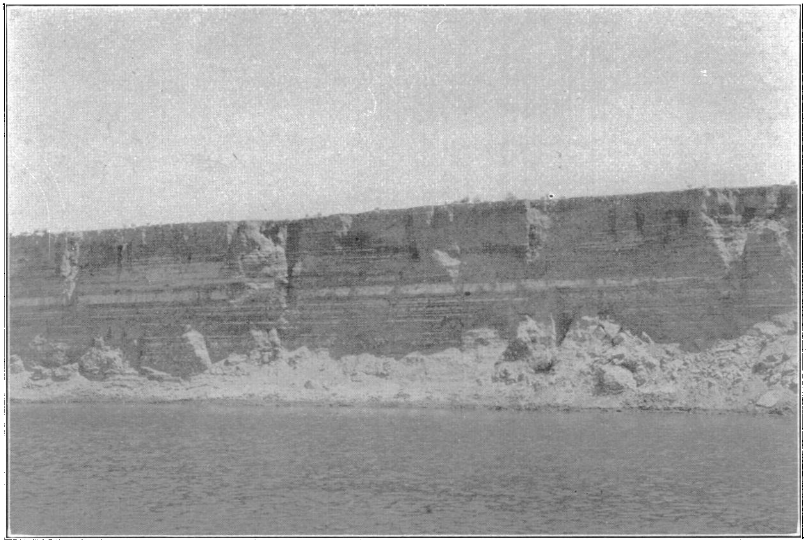

FIG. 30—Finely laminated clays, silts, and sands of Lake Minchin above (north) Fairweather Gap. Their visible portion is here 30 feet thick and in places have as high as 15 to 30 thin, and about 7 thicker laminations to the inch. They are in strong contrast to the thick-bedded deposits of Lake Ballivian. They lie only on the valley floor, whereas the deposits of Lake Ballivian are now in most places eroded back some distance from the river.

than offset the greater product. Since the prices of all merchandise were, in the pre-railroad days (before 1851), largely controlled by the rate of transport from the coast ports, and this in turn by the abundance of free pasture and the price of hay, the wet years always carried the advantage of cheaper goods, and this advantage was shared by all. Those who had forage to sell, therefore, gained most in years of moderate dryness, when there was neither free pasture nor abundance of water for irrigation.

At the present time the nitrate industry alters this condition. Its steady demand upon the alfalfa meadows for the thousands of mules that are required for the caliche carts maintains the prices at a higher level, and many years of rain are now marked by a much higher level of prosperity for the landed proprietors. This in turn helps the poor laborer, the vagrant shepherd, and the small landowner who in former times was often pushed to the wall. Life has therefore become easier and safer; the former waste in years of rain and distress in years of drought has been displaced by organized commerce in response to the steady market in the nitrate desert. But the people have not in any sense lessened their dependence upon the rains. In fact, they have greatly increased it. A new industry and the general organization of commerce in which the railroad plays a large part have merely turned their dependence into new channels.

In the wet years, imported cattle from Argentina winter in the hills and are driven down to the valleys ready for the market. In dry years they arrive lean and weak after their long journey across the lofty desert mountains, and must be fed on rented pasture in the alfalfa meadows of the valley people. When dry years occur in succession the prices of forage may rise faster than the prices of meat, since the owner's draught animals are his first care. As a result the drovers stop their importations, for with rising prices the small buyer who is continually becoming poorer at last is unable to buy meat at all. If the dry period continues, mules may be driven from Chile into Argentina, there to winter on cheaper pasture until the return of normal conditions in the desert.

Formerly the mining industry absorbed not only the chief part of men's energies in the Copiapó region, but also most of the products. Cattle were then imported from Argentina for the mines, just as they are now imported for both the mines and the nitrate fields farther north. Great troops of hired mules were employed by the mine owners to carry copper and silver ores to the coast ports. Both mules and cattle had to find subsistence in part on the desert upland where short grasses spring up after the winter rains. In the history of the mines there are many instances of distress owing to the poor state of the pastures. Exploring expeditions were early sent out to discover new routes along valleys where showers had been reported by travelers, and in at least one instance a new route led to the development of a new port as short-lived as the pastures to which it owed its origin. When a period of dry years set in all transportation had to be stopped, the ore accumulated at the mines, and chartered ships were sent back to Swansea either empty or half loaded. Thus dividends were passed more than once at London because of the lack of a few showers in Chile.

When the alfalfa fields dry up and neighbors are in sharp rivalry over water diversion the old colonial rule of the "turno" is enforced. A commission is selected with power to enforce water regulations. These require that only once every fourteen days may a landowner divert water to his fields and then in proportion to their size. But it is impossible to police the whole valley from the Cordillera to the town. Each landowner must therefore be to some extent his own commissioner and detect and punish unlawful diversion. Feuds arise and grow the more bitter because the valley is restricted in population and families are intimately related by village or social groups scattered up and down the valley. The quarrel of one thus becomes the quarrel of the group to which he belongs.

Said the manager of one of the mining companies at Copiapó in 1838: "It would be difficult for anyone who has not experienced it to believe in the robbery and quarreling constantly on foot with respect to rations of water in this extraordinary and desert district, along the whole course of the valley from the town to the Cordillera, a distance of ninety miles—all the lands being dependent for irrigation upon a little contemptible stream of water whose volume at any one point is barely sufficient to fill the wear of an ordinary flour mill.

"Notwithstanding the regulations that have been made by the authorities—and heavy fines imposed on infringements—such are the difficulties of proof and such the localities of the district that abuses can be practiced with impunity. . . ."

On more than one occasion I got myself into an embarrassing position on account of seemingly harmless questions about water rights. I soon found that a social guide was needed—one who could tell me who were friends and who were enemies. At times it was necessary to exercise great care in receiving various officials and townspeople who were kind enough to call upon me, lest there should be formed an uncongenial group. It would be difficult for A to join B in polite explanations when A's servant had but lately broken B's servant's head. B would not feel nearly so badly about the broken head as about the alfalfa field that would now be ruined on account of the sudden interruption in the process of stealing water from his neighbor's canal. It was pointed out to me that the Decalogue does not include water among the things that shall not be coveted, hence water diversion from a neighbor's ditch at three o'clock in the morning seems to the drought-stricken farmer to resemble theft less than intense business rivalry.

But there is a happier aspect to the picture. With what enthusiam a desert dweller still speaks of the years of abundance—when the rains came, and there was plenty for all. The influence of the seasons on the valley people is as marked as ever. In spite of a railroad, a higher degree of organization, and a position on one of the routes of world commerce, they find the rains a matter of deepest concern. When showers come cattle are driven to the free upland pastures. Between 1890 and 1892 the valley stock was sent into the hills, the owners lived in tents like true nomads, and in the plenty of those years forgot long-standing quarrels over water rights. The earth is then no longer a desert waste. Where sand and tough shrubs ordinarily hold sway there is now wild clover, knee-deep, luxurious. The erstwhile niggardly earth yields an abundance of food, as if suddenly awakened to generosity of its own free will—*sponte sua,* as Horace says. Flowers bedeck the light-green upland meadows. It is a year of rain!

Now that the nitrate fields are in a high state of development and in chronic need of laborers, the dry years in the southern valleys are times of migration to the northern desert. There they remain until they hear from relatives and friends that rains have brought plenty, whereupon they drift back to old occupations—the transport of merchandise by pack train, the cattle business, the production of alfalfa, or a host of minor projects which general prosperity encourages, if it does not create, and which general distress forces people to abandon.

THE LAKE SYSTEM OF THE BOLIVIAN PLATEAU

The work of the 1913 expedition in western Bolivia was confined to the solution of a problem that has long puzzled students of geography—the history and relations of the system of plateau lakes. Three distinct water bodies were formed in the Titicaca-Poopó basins, whereas in the past both shore forms and bottom deposits of the great depression in the tableland have been considered to be the products of a single water body whose shrunken remnants are the Titicaca and Poopó of to-day. The full discussion of the details with references to earlier views will be left to a later paper. It is sufficient here to outline the conclusions and the main facts on which they rest.

In 1907 I entered Bolivia from Chile via the Cueva Negra pass in the Cordillera Sillilica and found, on the western border of the Poopó basin, strand-lines of a vanished lake. This lake I propose to call Lake Minchin, after the late Juan B. Minchin of Oruro, whose studies of forty years ago mark the beginnings of our scientific knowledge of the Bolivian basins. Though I had only aneroid measurements of the elevations of its shores, it seemed incredible that the lake should ever have been several hundred feet higher than Lake Titicaca, as some have supposed. The old shorelines of the lake are also clearly visible on the Cerro de Oruro as at many other places, and everywhere they seem to be horizontal and below the level of Titicaca. The problem of the relation of Lake Minchin to Lake Titicaca is complicated by the presence of lake deposits at a few points about the border of the Titicaca depression. It was adding confusion to complexity when certain students began to assume that the widely scattered deposits of a still earlier lake system were part of a great series made in a single lake of gradually diminishing size. Such a conclusion identified as one not only lakes in different basins, but also lakes belonging to distinct geologic epochs and possibly even to distinct periods.

From brief studies at various points on the border of the Titicaca-Poopó basin I reached the conclusion that the Desaguadero Valley held the facts most necessary for a correct solution. A short visit in 1907 to the head of the Desaguadero Valley resulted in a few new data, but left the most important part of the problem unsolved. I therefore made arrangements in 1913 to descend the Desaguadero, if need be to Lake Poopó, and to get critical evidence bearing on the succession of lakes and their relations. Happily, the necessary relations were encountered about eighty miles below Lake Titicaca, with the following results:

Lake Minchin—a temporary lake of glacial times—extended up the Desaguadero Valley beyond Concordia to a point about thirty miles south of Lake Titicaca and thence southward over the whole Poopó basin. Finely laminated clays lie on the floor of the

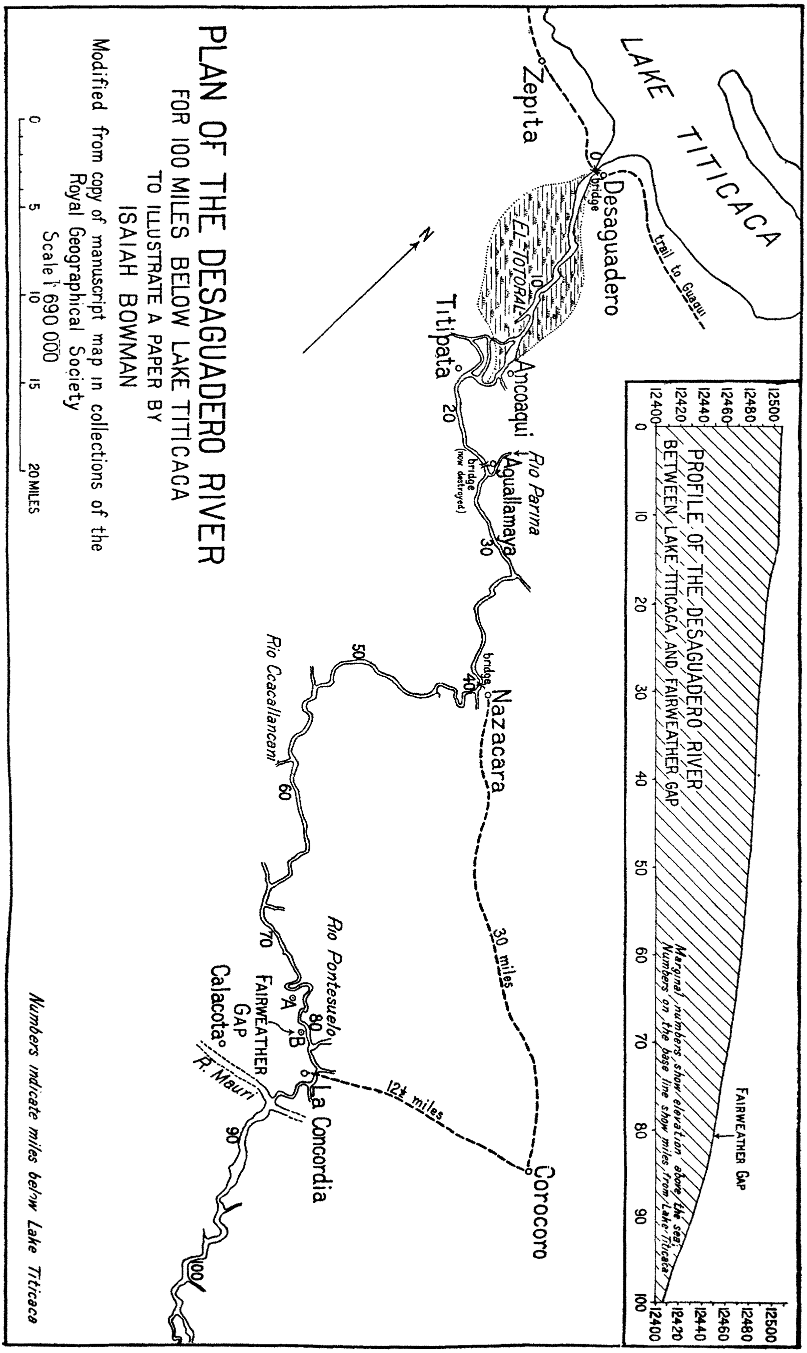
LAKE TITICACA
trail to Guaqui
Zepita
Desaguadero
bridge
EL TOTORAL
10
Titipata
Ancoaqui
20
Rio Parina
Agualamaya
bridge (now destroyed)
30
N
bridge
40
Nazacara
50
Rio Ccacallancani
60
30 miles
70
Rio Pontesuelo
A
B
80
FAIRWEATHER GAP
Calacota
R. Mauri
12½ miles
La Concordia
90
Corocoro
100
PLAN OF THE DESAGUADERO RIVER
FOR 100 MILES BELOW LAKE TITICACA
TO ILLUSTRATE A PAPER BY
ISAIAH BOWMAN
Modified from copy of manuscript map in collections of the Royal Geographical Society
Scale 1 : 690 000
0
5
10
15
20 MILES
Numbers indicate miles below Lake Titicaca
PROFILE OF THE DESAGUADERO RIVER
BETWEEN LAKE TITICACA AND FAIRWEATHER GAP
12500
12480
12460
12440
12420
12400
0
10
20
30
40
50
60
70
80
90
100
FAIRWEATHER GAP
Marginal numbers show elevation above the sea.
Numbers on the base line show miles from Lake Titicaca.

Fig. 31.

valley and are interpreted as bottom deposits. They indicate that Lake Minchin stood from thirty to forty feet below the present level of Lake Titacaca. Their elevation coincides remarkably well with the highest strand-line at Oruro, 125 miles to the southeast, and the elevation of the shorelines at Llica toward the Chilean frontier, 200 miles south. It thus seems established that Lake Minchin never reached Lake Titicaca. The bearing of this fact may be appreciated from the statement that it was to the coalescence of these lakes and their former greater elevation that students formerly ascribed the assumed higher strands of Lake Titicaca.

This conclusion was rather clearly forecast, though by no means established, by the work of 1907. The climax of the present study was the interpretation of the relations of both Lake Minchin and Lake Titicaca to a third lake which I propose to call Lake Ballivian, in honor of Don Manuel Vicente Ballivian, Bolivia's most distinguished scholar. At various points about the borders of Lake Titicaca and from fifty to one hundred feet above it there have been found in past years clay deposits containing shells similar to those now inhabiting the shore of the lake. But the deposits are of small extent and have associated with them no shore terraces or beach deposits that would make clear their origin. In the examination of clay outcrops in quebrada Carabaya, back of Guaqui, and in the hills at Tiahuanaco I found shells and reed impressions similar to those on the existing shore. They occur up to 125 feet above the lake and appear to be in a late stage of erosion, since they occur in scattered remnants and their associated shores have since been completely eroded away.

At the southern end of the Totoral, a great swamp in the Desaguadero Valley just below the outlet of Titicaca, there is a little village of Uros Indians. The houses are built at the top of a low bluff on whose face there outcrops a white marl containing identically the same shells. The elevation is only a few feet above Lake Titicaca. The farther down the Desaguadero one goes the higher these marly deposits lie, until at Nazacara they outcrop 100 feet above the river. They also become interstratified with sand, silt, and brown clays. The latter group of deposits increase in thickness down valley and, ten miles above La Concordia, they terminate on the slopes of a broad ridge which crosses the valley. At the point of termination they are 210 feet above the Desaguadero and 160 feet above Lake Titicaca. These measurements are based on both hand leveling and aneroid determinations with the river as a base. The river gradients and the exact elevations at every

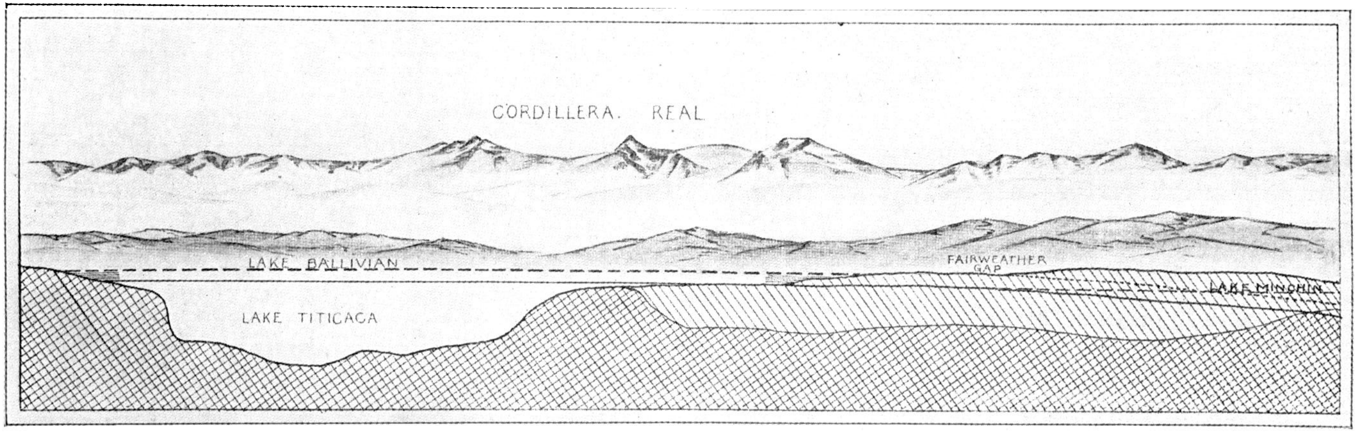

FIG. 32—Diagrammatic sketch of the lake system in the Titicaca-Poopó depression. The profiles of Titicaca and the Desaguadero are drawn to scale; likewise the various lake levels; but the Cordillera Real and the intervening smooth-contoured range are sketched only in the most general way. Looking east. (For details at Fairweather Gap, see Fig. 33; see also Figs. 28 and 29.)

point we were able to secure from a manuscript map made by engineers of the Peruvian Corporation. This had been deposited with the Royal Geographical Society, and to their courtesy in allowing a copy to be made we owe more than we can here express.

Dr. G. H. Dall of Washington has identified some of the shells from Ancoaqui as probably early Pleistocene. For our present purpose their precise age is not a matter of great importance. The points of chief interest are: (1) They are the deposits of a lake that once stood 150 feet above Lake Titicaca; (2) the outlet of the lake in which they were deposited was cut down and the deposits themselves deeply and widely eroded before the last glacial epoch of the Central Andes began; and (3) deposits of glacial Lake Minchin lie on the floor of the Desaguadero Valley cut into the beds of the earlier lake. The outlet of Lake Ballivian is now a gap in the hills above La Concordia (Figs. 28 and 29). To it I have applied the name "Fairweather Gap," after F. W. Fairweather of Guaqui, to whom I owe a heavy debt of gratitude for assistance in transportation and for his interest in the problems of the Desaguadero Valley. The chief relations of the three lakes, their deposits and outlets, are shown in the accompanying photographs and sketches. A full discussion will appear in a later number of the *Bulletin.*

A journey about Lake Titicaca, with frequent stops for the examination of apparently critical localities, leaves me still in doubt as to certain important chapters in the history of the basin. In many places one cannot find remnants of the clays of Lake Ballivian in protected places where they would be most likely to survive. Furthermore, the clays and marls of the Desaguadero Valley are unequal in height, though their inequality seems to be confined to the vicinity of Lake Titicaca. In the middle stretches between Fairweather Gap and Ancoaqui they appear to be horizontal. These facts are scarcely more than hints that the Titicaca region may have been subject to deformation at the end of an early lake period and that through this deformation it gained its present attitude, which it has kept through a cycle of erosion so prolonged as to soften its tributary slopes and all but remove former shore terraces and border deposits.

The numerous shore lines to which Agassiz referred in 1879 do not exist. Lake Titicaca has stood at or near its present level ever since the period in which its outlet cut down Fairweather Gap to about its present level. That it has long been at this elevation is shown by the fact that it has suffered no significant change of level during both the glacial and postglacial periods. Fifty-five miles below Lake Titicaca the deposits of glacial Lake Minchin still remain, but slightly eroded, on the floor of the Desaguadero Valley. Compared with Lake Minchin, Lake Ballivian is old and was the product of a stage of deformation intermediate between that which defined the great central basin region of Bolivia and that which gave the land its present attitude.

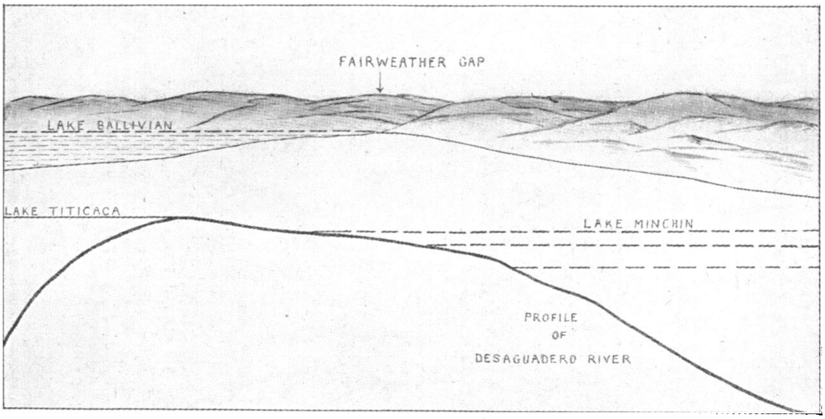

Fig. 33—Sketch showing relations of lake levels at Fairweather Gap. Fig. 32 is too small to show these relations accurately. Lake Minchin—a temporary lake of glacial times—came into existence long after the Desguadero had cut down its valley from the level of Lake Ballivian to that of Titicaca.

It is an interesting consequence of the above conclusion that the great salt deposits of the salinas west and south of Lake Poopó are not alone the accumulations of the Titicaca discharge or of temporary Lake Minchin of glacial times. They represent also the accumulations of that long period when Lake Ballivian discharged south through Fairweather Gap, a period of time possibly several thousand times longer than that representing the duration of Lake Minchin.